A Physics-Based Starting Model for Gas Turbine Engines, Phase I

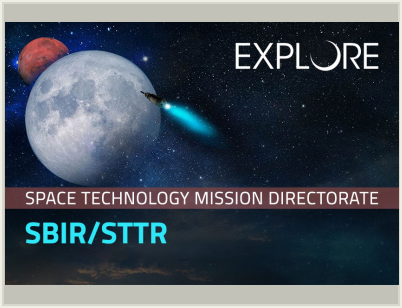
Completed Technology Project (2009 - 2009)

Project Introduction

The objective of this proposal is to demonstrate the feasibility of producing an integrated starting model for gas turbine engines using a new physics-based combustion dynamics model that accurately simulates flow interactions among the compressor, combustor, and turbine. Replacing conventionally costly guess-and-test techniques, this new process for starting system analysis, design, and optimization promises a new generation of predictive capability that will allow system engineers to design engines with higher fidelity and eliminate the need for multiple iterations and testing cycles found in current industry practice. EcoPro Technologies' physics-based starting model is built from an innovative solution algorithm which solves the 1-D speed-dependent conservation equations of mass, momentum, and energy for each starting system component. From this integrated algorithmic model, we will be able to achieve predictive capabilities for the most vital engine dynamics, including starting/transient instabilities of combustor flameout, compressor surge and over-temperature shutdowns. Our integrated design tool allows for complex starting simulations, thus enabling successful engine design and modeling with rapid determination of sensitivities with respect to all engine design variables and constraints. This empowers engineers to choose optimized design directions without violating constraints and make appropriate design changes to engines prior to costly manufacturing and testing.

Anticipated Benefits

All commercial aircrafts have design requirements for reliable altitude starting. Some newer commercial aircraft under development additionally demand ETOPS-proven starting requirements of > 99.99% reliability for altitude environments up to 43,000 ft. With these stringent design requirements, an altitude starting model which allows clear analytical understanding and physical predictions during high altitude starts for gas turbine engines is in urgent need commercially. In addition to being used for NASA applications, EcoPro Technologies' altitude starting model will be commercialized as a gas turbine industry design "best-practice" to help improve engine starting reliability to meet ETOPS-proven starting requirements of >99.99% reliability for altitudes environments up to 43,000 ft. Achieving altitude starting capability is one of the most important design requirements for any gas turbine engine used in both military and commercial aircraft. Any shortfalls of altitude starting performance discovered during qualifications or flight tests will cause expensive engine re-design and significant schedule delay. Therefore, NASA can apply this innovative R&D program in the following ways: 1. The first and most urgent potential application of this R&D program is for NASA to use this model as a conceptual design tool for mitigating program risks of engine re-design. 2. Optimizing engine transient/starting performance including altitude light-off, starter cut-off, and transient load operations during preliminary and detailed design. 3. Troubleshooting any existing development or production engine starting problems including fail-to-lights, combustor



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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Glenn Research Center (GRC)

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

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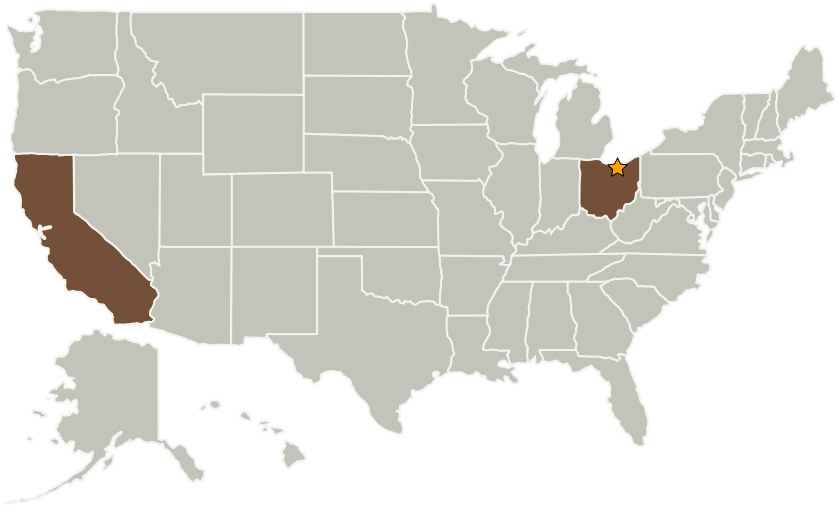
flameouts, compressor surges, over-temperature shutdowns and any starting instabilities. 4. The starting model also can be used to help identify the component failure modes and improve engine starting reliability.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Glenn Research Center(GRC)	Lead Organization	NASA Center	Cleveland, Ohio
EcoPro Technologies, LLC	Supporting Organization	Industry	Berkeley, California

Primary U.S. Work Locations	
California	Ohio

Project Management

Program Director:
Jason L Kessler

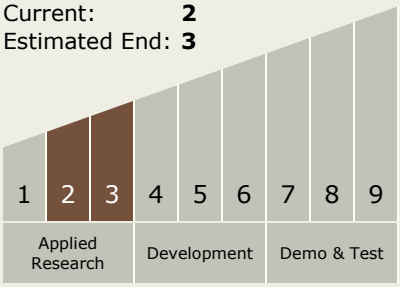
Program Manager:
Carlos Torrez

Project Manager:
Jonathan A Seidel

Principal Investigator:
Angela Chen

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX01 Propulsion Systems
  - TX01.3 Aero Propulsion
    - TX01.3.4 Pressure Gain Combustion